TRANSMITTAL SLIP | DATE

TO: [redacted]

ROOM [redacted]

REMARKS:

This Printer contains some good principles but is too sensitive for continuous use

FROM [redacted]

ROOM NO [redacted] SION

FORM NO. 241 1 FEB 55 REPLACES FORM 36-8 WHICH MAY BE USED. GPO : 1957—O-439445 (47)

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CONTRACT FILE

Final Report On The
LOW DISTORTION
HIGH RESOLUTION PRINTER

25X1

31 October 1963

SUMMARY

The Low Distortion High Resolution (LDHR) Printer was designed and built as part of Task 2, [redacted] Requirements of the contract called for a photographic printer that featured continuous operation, no image distortion, and best print definition possible. An engineering model of this printer was developed and built in the Apparatus and Optical Division.

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Tests of the engineering model showed that the printer may be considered a qualified success. During the tests it was apparent that several changes could be incorporated that would improve machine performance and facilitate operation. These changes were not made because of the additional costs involved and because of the ability of other printer techniques to achieve the current requirement for high definition and low image distortion. Because these results were obtainable on a simpler mechanism, additional modifications and continuation of further testing of the LDHR were discontinued.

It is recommended that no additional printers of the LDHR design be built, but that advantage be taken of the prototype machine for special printing tasks and experiments.

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Illustrations

INTRODUCTION

Scope

As part of Task No. 2, [redacted] was authorized to design and build an engineering model of a Low Distortion High Resolution Printer. This continuous running "slit printer" was to be capable of operating at 60 feet per minute with no image distortion and capable of producing the best possible definition in the print for aerial photography in 70mm to 9.5-inch wide rolls of film. 25X1

Background

Early in the design stage it was decided to incorporate two features to eliminate image distortion:

1. A printing gate that would hold the original and print stock in intimate contact as they move past the exposing source in a flat plane.

2. Constant force (weighted) tension arms with servo control on the film spool torques to provide balance and constant tension on both the original negative and the duplicating film as the roll size changed during operation.

The flat film gate avoids the stretching effect of one film emulsion surface and the compression effect of the other that is encountered when the films are flexed over a drum surface during exposure. The balanced film tension prevents slippage of one film relative to the other when they are running through the printing gate, and prevents the differential distortion that might come from uncontrolled and varying tensions in the machine.

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MACHINE DESIGN

Cabinet

The LDHR Printer is installed in a cabinet approximately 70 inches high, 40 inches wide, and 32 inches deep (see Figure 1). Compartment doors provide access to front, sides and top of the printer. The film compartment is pressurized with filtered air to prevent entry of dust particles.

Behind the electrical control panel, which is located below the doors to the film compartment, is the power supply chassis mounted on a sliding drawer. This chassis controls the light source; the drive motor; the tension system; the blowers for cooling, dust removal, and for film cleaning; the vacuum pump; and the switches for operation of the printer. The voltage regulator and the variable autotransformer (which controls the light source) are independent of the power control chassis.

In the cabinet under the power supply are the vacuum pump and three blowers (one for the film cleaning station, one for the lamp house cooling, and one for pressurizing the film compartment). The vacuum pump and three blowers have resilient mountings to reduce vibration. Lengths of flexible tubing connect each blower to its station and to its point of exhaust or intake.

Cleaning Station

The cleaning station (see 1, Figure 2) located near the entrance to the film gate, consists of four 10-inch static eliminators (inductors) and two pairs of rotating brushes. The complete unit is connected to a centrifugal blower intake which carries away the dust and dirt particles removed by the brushes.

Light Source

The light source (see 2, Figure 2) is a 1000-watt, tungsten filament lamp. The intensity of this light source is measured by the Color 25X1
Analyzer (EP-1000) and controlled by the variable autotransformer in the line. Collimated light at the printing mask is provided by a condenser lens system large enough to cover all film sizes.

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Conversion Units

The printer is provided with interchangeable conversion units to permit handling various width films. Each conversion unit has a mask of predetermined size (see 1, Figure 3a). These masks provide exposure slit widths that are selected to make exposure times equal the time of a whole (not fractional) number of cycles of the electrical power supply and therefore reduce banding effects.

Printing gates are also a part of the conversion units for the five different film widths (70mm, 5-inch, 6.6-inch, 8-inch, and 9.5-inch film widths). Edge vacuum chambers on the gates will accommodate the following film thicknesses after minor adjustment of the four micrometers for the vacuum chamber covers (see 2, Figure 3a).

a. Original Type Material	Typical Thickness
Thin base Estar support	.003 inches
Standard base Estar support	.0043 inches
Standard base acetate support	.0055 inches
Heavy base Estar support	.0075 inches
b. Duplicating Type Material	
Standard base Estar support	.0045 inches
Standard base acetate support	.0055 inches
Heavy base Estar support	.0075 inches

Film Transport System

The film drive is designed so that negative and duplicating film can be driven at a synchronous speed of 40, 60, or 80 feet per minute by a multiple speed drive hysteresis synchronous motor. The drive roller (see 4, Figure 3b) which is the upper left roller in each conversion unit, is coupled to a worm gear box with multijaw couplings which provide easy interchangeability.

The supply and takeup spindles for both negative and duplicating film will accommodate "MIL Standard" flanged spools with flange diameters from 5 3/8 inches for 200-foot rolls to 7 5/8 inches for 500-foot rolls with a core diameter of 2 1/8 inches. The film tension is adjustable with a maximum of 5 pounds and a minimum of 1/2 pound.

Tension is controlled by weights and an adjustable moment arm. Each arm has five detents to indicate the correct position of the tension drive for a particular film width.

The tension control weights (see 2, Figure 4) are damped to reduce oscillation in the film transport systems. This damping is accomplished by a piston, which moves in a cylinder filled with Dow Corning 200 Fluid, attached to each weight. A potentiometer coupled to the movement of each tension arm controls the torque applied on the associated film spool so that it balances the film tension produced by the tension roller.

Interlock System

To prevent printer operation before setup is completed, interlocks (microswitches) are installed as follows:

a. On the drive roller pressure carriage and on each vacuum chamber cover, to insure that they are in position before a print run is begun.

b. As excessive-loop switches for the takeup tension arms only.

c. As loss-of-loop switches on each tension arm.

d. On the compartment doors.

The interlock system also shuts off the machine when either the duplicating or negative film runs out.

Control Panel

The printer control panel (see Figure 5) consists of a 3-position MAIN switch; a JOG button; a RUN button; a STOP button; a LAMP TEST switch; a VACUUM (Pump) TEST switch; an illuminated circular dot to show whether the printer is off, on, or running; and two fuses.

OPERATION

Before operating the printer, the conversion unit for the film width to be run should be installed, the supply and takeup spindle lengths adjusted to the spool width, the tension properly adjusted, the micrometers for the vacuum chamber covers adjusted, and the correct lamp intensity determined and set. Figure 6 shows the printer ready to run.

After these preliminary checks and adjustments have been made, the printing of duplicate films can be started by the operator. This run will continue until the negative or duplicating film supply is exhausted, the doors are opened, the main switch is turned to any other position but ON, or the STOP button is pushed. If either film breaks, operation of the printer will be stopped automatically.

TESTS

The completed assembly was tested by the Quality Control group to determine the general characteristics of the printer in the following categories.

1. Air Gate
2. Resolution
3. Distortion
4. Exposure system
5. Film handling

Except where otherwise noted, Kodak Fine Grain Aerial Duplicating Film, Type 8430 was used throughout the tests as the dupe material.

Mechanical

One of the unique features of the LDHR Printer is the method of handling the materials on a thin cushion of air in the printing gate. Mechanical tests were run to determine the adequacy of this design and the tests indicated that contact between the films in the gate was not always consistently good. This appeared to be caused by two factors.

1. Thin base (.0025 Estar) original negative material showed a tendency to wrinkle as it entered the leading pinch roller of the gate. This condition was confirmed by the use of a grid test object whose image appeared as dark diagonal lines in the print.

2. The pressure drop in the air channels at the sides of the gates appeared to be too low. This situation required that the air channel be set very close to the film: so close that slightly imperfect splices would not pass through.

The wrinkle problem might be eliminated by altering the film path to provide more wrap on the pinch roller. Since a redesign effort would have been required to prove this theory, the possible improvement that would result is conjecture.

Higher pressure drop at the air channels can be provided by increasing the capacities of the vacuum pump and vacuum lines.

Two other minor problems were noted. One involved a loose fit of the hinges on the edge vacuum chamber covers in the conversion units. This situation could be solved by tightening the hinge elements that surround the hinge pin. The other problem concerned changing conversion units. Operator training should emphasize careful and slow movement while sliding the unit into place to prevent damage to the coupling jaws.

Resolution

Charts having 650 and 793 lines per millimeter and 1000-to-1 contrast were printed onto the Type 8430 film. These tests were run with each size conversion unit installed in the Printer, and the results in each case follow:

Conversion Unit	Resolution (Lines/mm)
70mm	362 to 406
5-inch	317 to 353
6.6-inch	278 to 317
8-inch	278
9.5-inch	353

Except when using the 70mm unit, resolution across the film width was occasionally inconstant. The table states the best resolution obtainable. This condition was intermittent and some tests rendered center-to-edge resolution as indicated in the table.

Further investigation of the condition, whereby clear negative film and unprocessed duplicating film were run and observed as they passed the exposure slit, revealed that contact between the films was erratic. This was attributed to the low pressure drop in the air channels at the edge of the vacuum chamber as mentioned above.

Distortion

Distortion produced by the printer is a difficult characteristic to measure because of the presence of other sources of distortion such as processing and change of ambient temperature or humidity.

However, the amount of distortion from the printer-plus-process combination was determined by the change in the length of a line one meter long scribed onto seven-mil Estar base. This original was then printed onto Type SO-117 film which also has a seven-mil Estar base. The results include distortion caused by both the LDHR Printer and the processing of the film.

The measured change was approximately 0.4 mm of elongation for printer plus process. The expected change due to processing alone is on the order of 0.01 percent shrinkage, which leaves the distortion attributable to the printer to be about 0.05 percent elongation.

Distortion tests were not performed on a wide range of dupe materials because whenever distortion is a problem, the more stable seven-mil base materials would be the natural choice.

Exposure System

The exposure uniformity produced by the aplanatic collector lens is the best ever obtained on a continuous contact printer. Log exposure variation across a 9.5-inch wide print appears to be in the range of 0.04 density units. In addition, no streaking caused by the exposure system was observed.

25X1 The [redacted] color analyzer indication of relative output of the tungsten light source is accurate. A 0.10 change on the analyzer scale rendered a log E change of 0.14. This result is very close to 0.13 log E change obtained from a 0.10 change with a neutral density filter from the Wratten 96 series used in other printers.

Contrast in the printed film off from the LDHR Printer is similar to contrast achieved with printers that use high pressure mercury lamps. The contrast value is a 1.35 slope from an A-1 step tablet original.

The tungsten lamp exposure source provides a maximum effective intensity that can print through negative densities up to 2.2 upon the toe of the sensitometric curve of Type 8430 film.

Film Handling

Reprinting of frames within a roll of original negative would be difficult because there is no provision for fast rewinding (slewing) on the printer.

Splices in either the original negative or duplicating film to be used in this printer must be given careful attention. A misalignment of 1/32 inch, or more, where two films of exactly the same width butt together, is critical. Such a misalignment could cause a tear in the film or a jam up in the conversion unit gate.

CONCLUSIONS

As a result of the test described above, the Quality Control and Engineering groups have reached the following conclusions on the basic design concepts embodied in this printer. It should be recognized that these conclusions represent only the experimental evidence from a single machine and are not necessarily applicable to other configurations of the same concepts.

Air Gate

1. The air-gate principle is a valid technique for safe handling of films.

2. Dimensions are critical and cannot be arbitrarily increased for more clearance without creating problems of proper air flow.

3. Maintaining flatness in an air gate becomes a more difficult problem with thinner materials.

4. Because of the critical adjustments necessary, air gates may find their greatest use in cases where the same materials, in the same sizes are used for long periods. Changing sizes and materials produces a need for readjustment and consequent delays.

5. If material is to be used in an air gate, splicing tolerances are somewhat more critical than normal.

Resolution

1. The printer as designed is satisfactory for producing continuous duplicates with high contrast resolution of the order 270 to 350 lines/mm. It is inconsistent at resolutions higher than 350 lines/mm on the wider materials.

2. Careful attention must be given to air flow and edge conditions on the wider materials to insure good resolution across the film width.

Distortion

1. The printer produces a small (.05%) elongation in the dupe material. Such distortion may be insignificant compared to other distortion sources in any but the most carefully controlled conditions.

2. Lateral distortion was not adequately checked to be reported.

Exposure

1. The design of light sources and collector lens produce an exposure of excellent uniformity across 9.5-inch wide film.

2. The control and monitoring of the lamp intensity are accurate and easy to use.

Film Handling

1. The tension control system is excellent and would be advised for any printer in which the ultimate care of film is necessary.

2. The printer as designed cannot be used for loop printing.

RECOMMENDATIONS

1. Although the printer passed most tests successfully, it is recommended that no further machines of this type be built for this application. The state of the printing art permits other printers of simpler design to equal or exceed the capabilities of the LDHR Printer for high quality continuous duplicating.

2. It is recommended that the engineering model be used for special printing tasks such as flashing test material. The addition of an idler roller would make the LDHR an excellent loop printer with good tension control.

3. The high intensity tungsten light source makes the printer desirable as a superior quality continuous color printer where resolution requirements have not yet reached as high values as in black and white films. It is recommended that a holder be added for color correction filters and that the printer be used for experimental color printing when it becomes necessary

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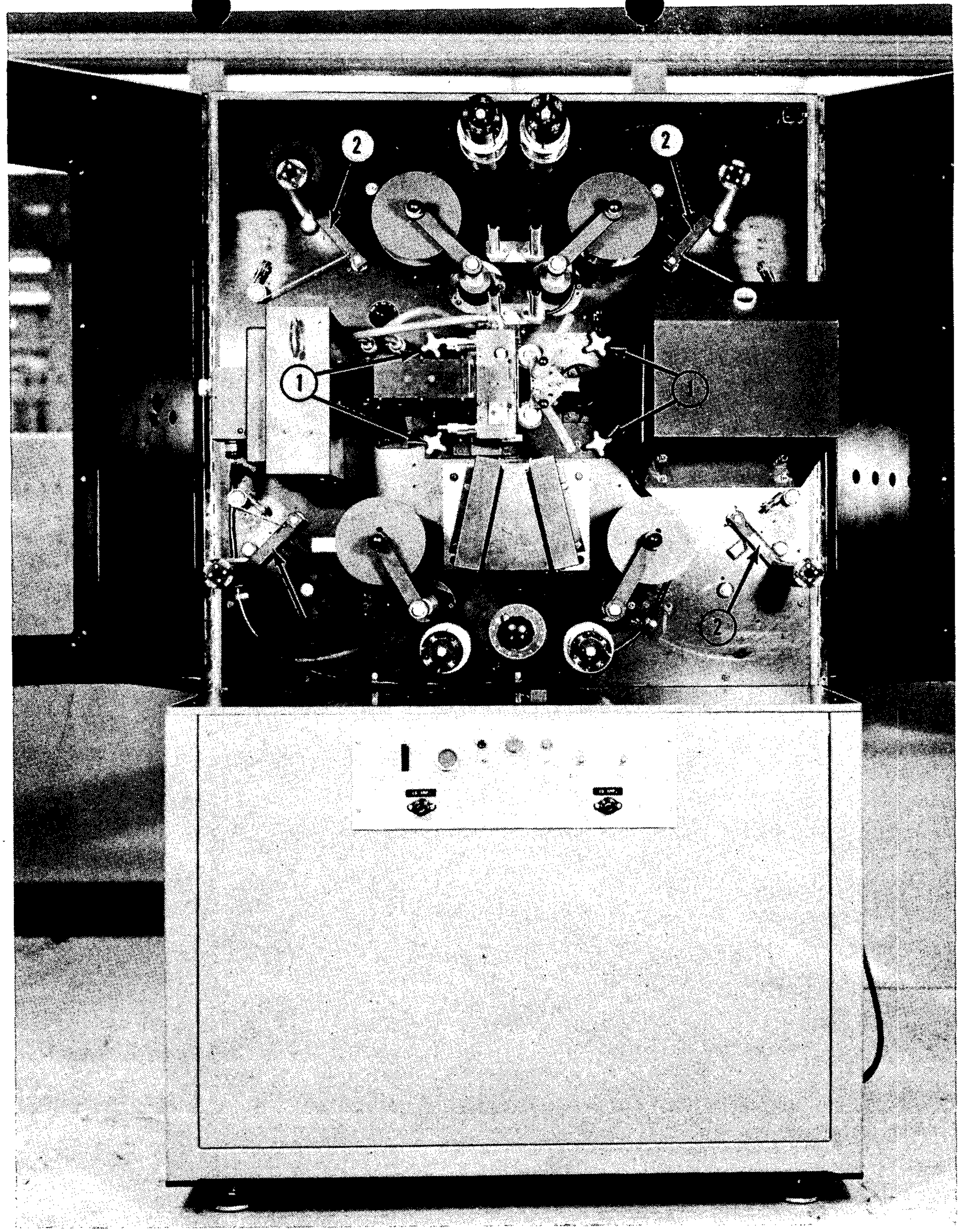
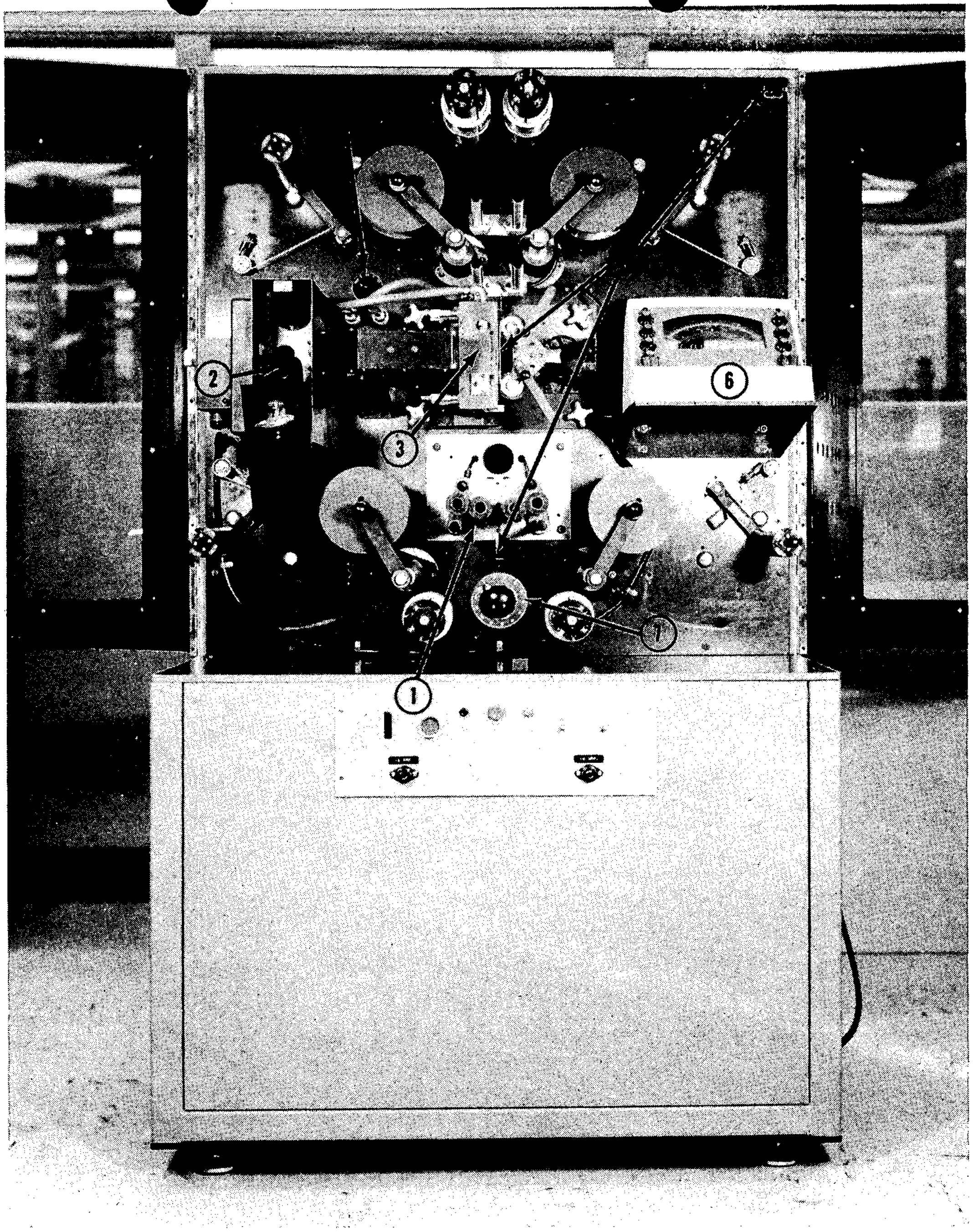


1. Hand Knobs for Fastening Conversion Unit to Printer

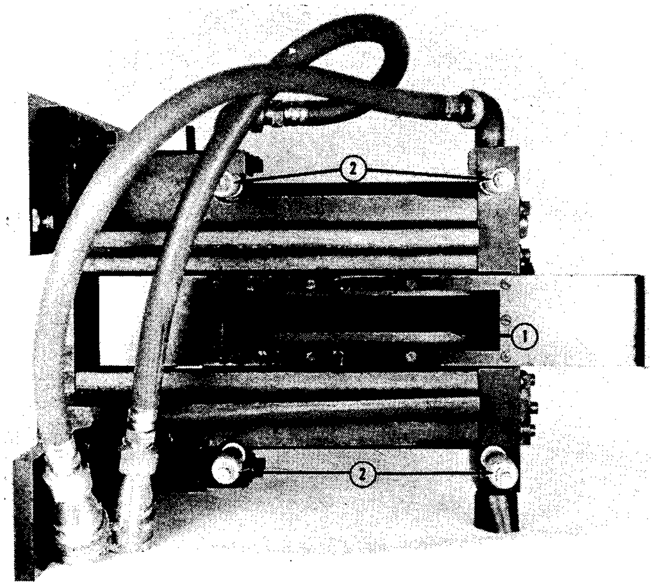
2. Tension Control Arms

Figure 1. Low Distortion High Resolution Printer



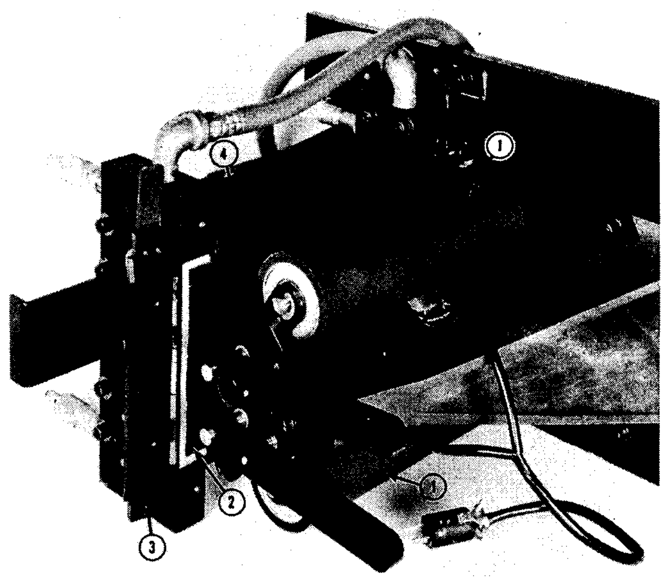
1. Cleaning Station (Cover removed)
2. Light Source (Opened to show lamp position
3. Conversion Unit
4. Tension Control Setting
5. Interlocks to Halt Film Drive
6. Analyzer for Light Intensity Control 25X1
7. Variac Knob for Light Intensity Control

Figure 2. Printer Showing Components Located in Film Compartment



1. Pre-Installed Mask
2. Vacuum Chamber Cover Micrometers

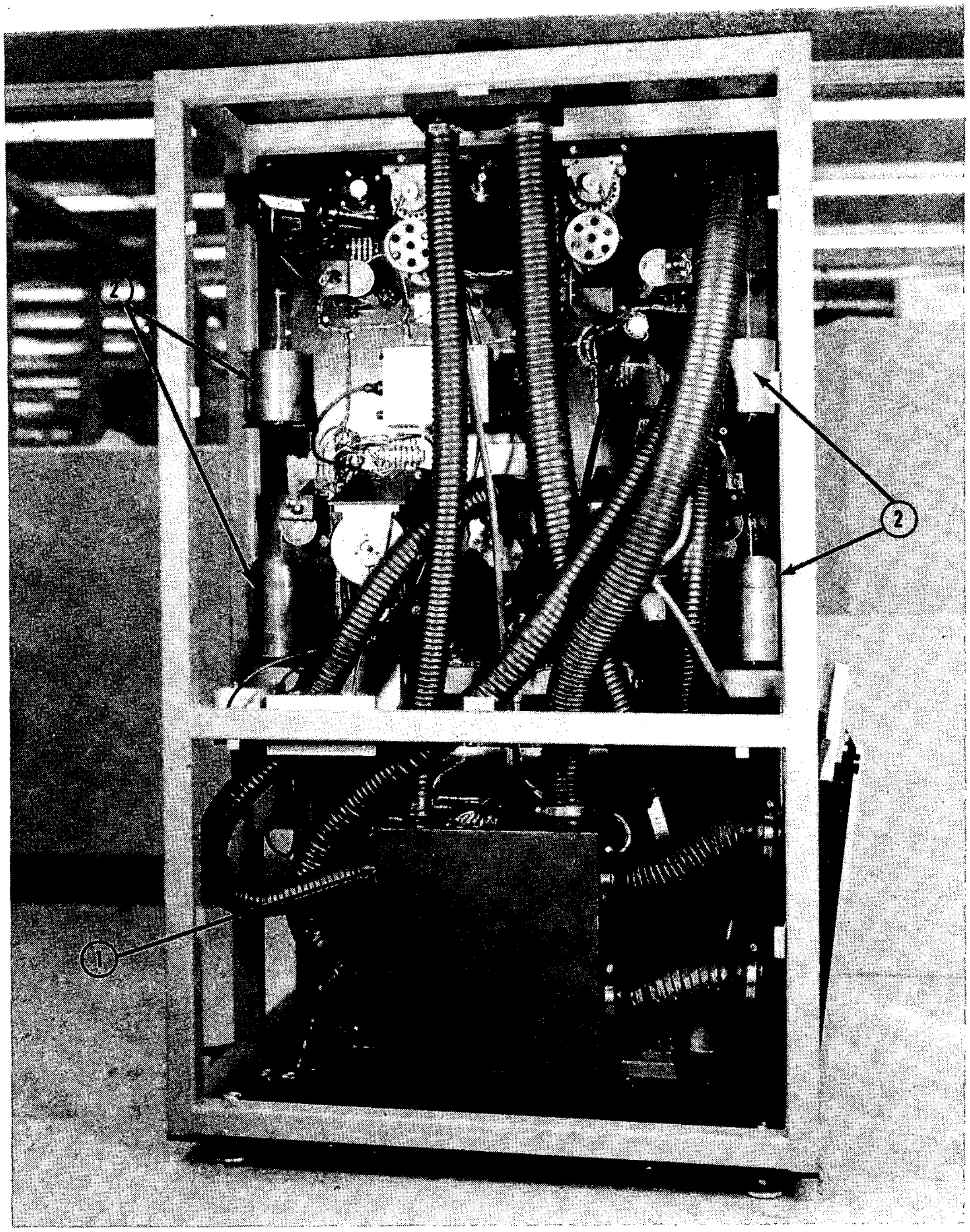
View A Side



1. Rubber Covered Rollers
2. Edge Vacuum Chamber, Left Side
3. Edge Vacuum Chamber Cover
4. Drive Roller

View B Oblique Front

Figure 3. Conversion Unit



1. Blower Housing

2. Weights for Tension Control

Figure 4. Printer, Rear View with Panels Removed

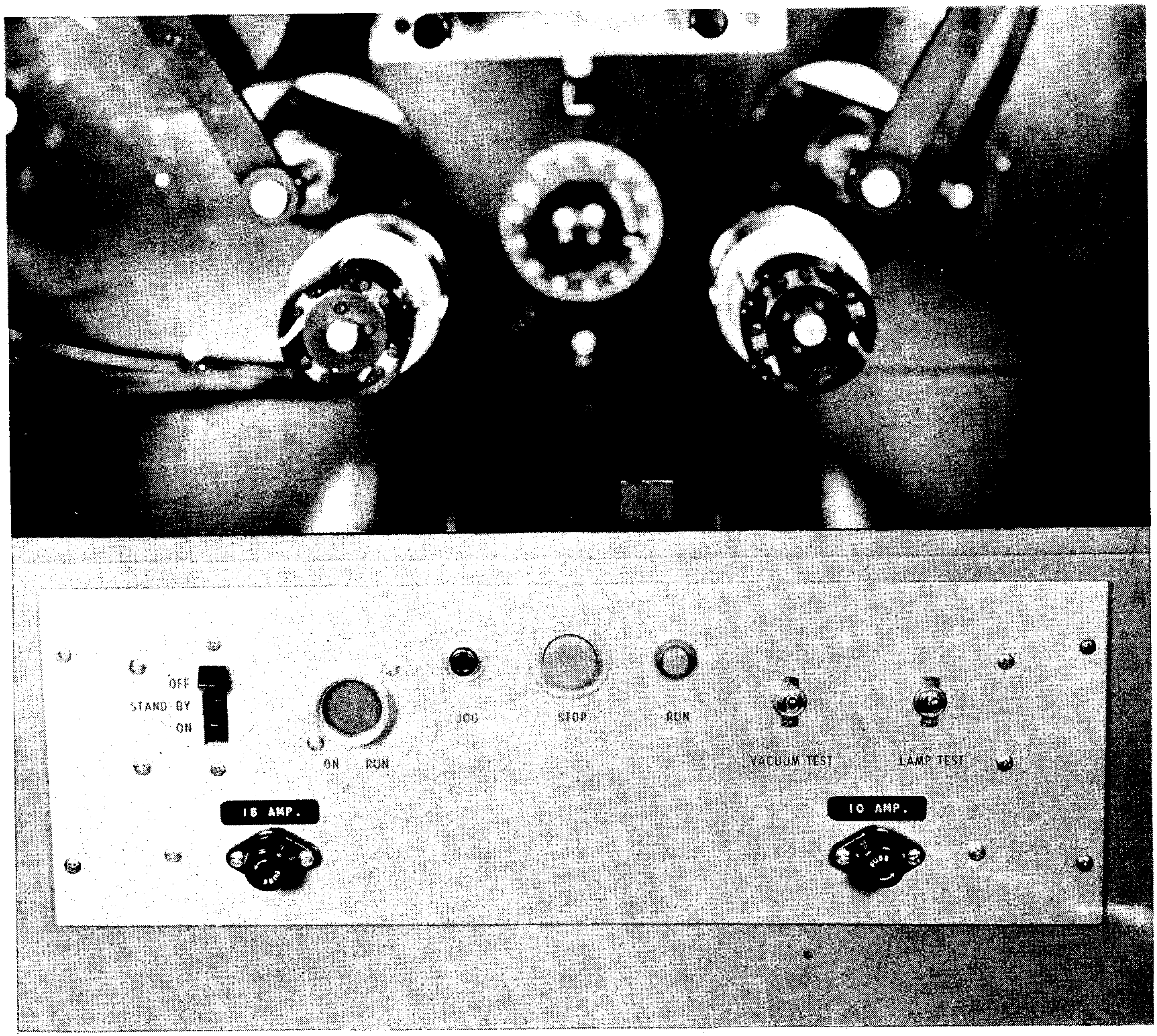


Figure 5. Control Panel

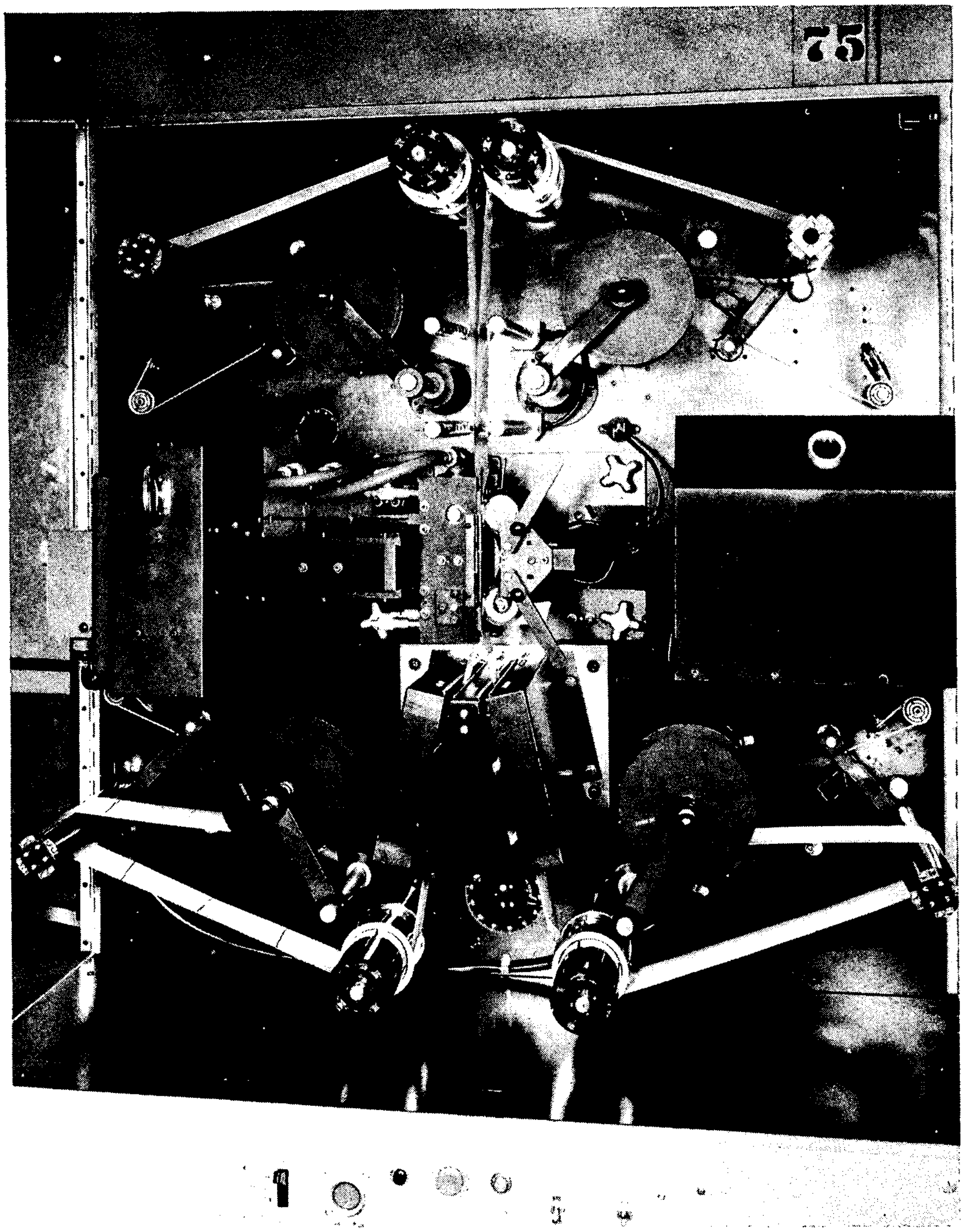
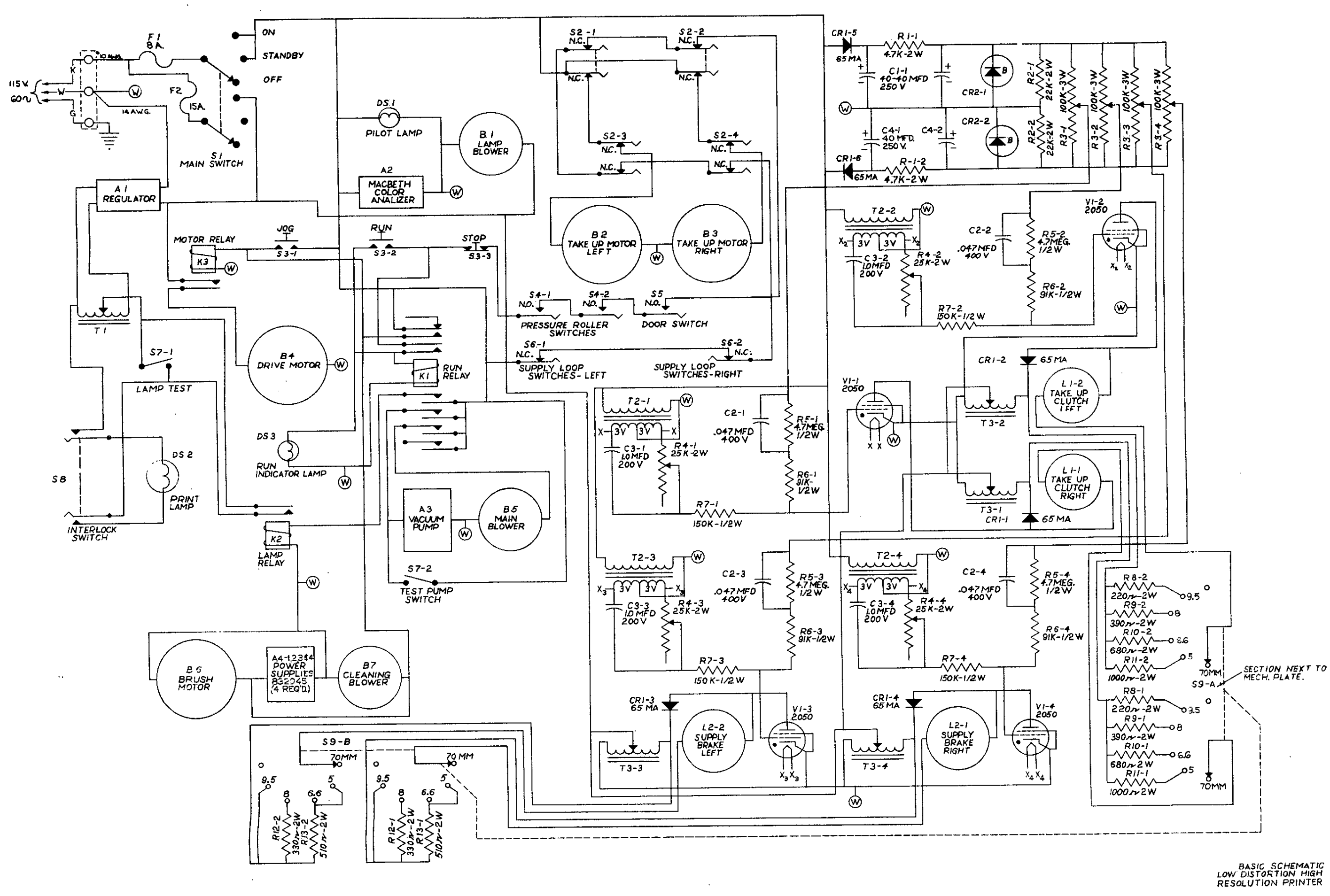


Figure 6. Printer Correctly Threaded



BASIC SCHEMATIC
LOW DISTORTION HIGH
RESOLUTION PRINTER

SECRET

SECRET